

(11) (A) No. 1 125 155

(45) ISSUED 820608

(52) CLASS 154-72.21

(51) INT. CL. B32B 31/00<sup>3</sup>

(19) (CA) **CANADIAN PATENT** (12)

(54) METHOD OF FUSION BONDING NON-ELASTOMERIC  
THERMOPLASTIC ELEMENTS WITH A BLOCK STRUCTURE  
ELASTOMERIC BONDING ELEMENT INTERPOSED AT THE  
BONDING INTERFACE

(72) Repik, Clyde P.;  
Leatherman, Alfred F.;  
Pickett, Gordon E.,  
U.S.A.

(73) Granted to Heller, William C., Jr.  
U.S.A.

(21) APPLICATION No. 311,039

(22) FILED 780911

(30) PRIORITY DATE U.S.A. (832,970) 770913

NO. OF CLAIMS 8

311639

JUN 8 1982 Abstract of the Disclosure 1125155

A solid block elastomeric bonding element

is interposed between the surfaces of non-elastomeric thermoplastic elements to be joined by a fusion bond.

5 The heat necessary for fusion bonding is obtained for optimum results by the incorporation of heat generating particles in the elastomeric bonding element. The particles are indirectly heatable by a high frequency alternating magnetic field or other suitable field for  
10 heating the fusion bonding element to a fusion temperature suitable for producing bonding of the non-elastomeric elements. A copolyester block elastomer bonding element is particularly useful for bonding polycarbonate, polyvinyl chloride or polyvinylidene chloride elements to each other,  
15 and a copolymer block elastomer is particularly useful for bonding polypropylene and high density polyethylene elements to each other.

20

25

30

Background of the Invention

This invention relates to a solid thermoplastic elastomer bonding film for fusion bonding or sealing of plastic elements to themselves and to other surfaces.

5 Plastic elements are widely employed in various products. Although thermoplastics such as polyvinyl chloride and the like can be readily bonded adhesively or thermally to themselves, various other thermoplastics are not readily bonded to another element. For example, polycarbonates, 10 polypropylene and the like are difficult to bond to another surface, particularly without adversely affecting the plastic material. For example, polycarbonate may be bonded to polycarbonate or other surfaces by ultrasonic welding, spin welding and the like. Such processes, however, have 15 generally resulted in embrittlement of the polycarbonate. Even with such processes, the polycarbonate cannot be bonded to certain surfaces such as glass.

Various adhesives have been suggested in which a liquid is applied between elements and the surfaces joined 20 by drying of the liquid adhesive. Recent adhesive agents employing particular liquid thermoplastic elastomers having a block copolymer structure and sold by Phillips Petroleum Company and Shell Oil Company are discussed in MODERN 25 PLASTICS ENCYCLOPEDIA, 1975-1976 edition. These liquid adhesives, however, do not provide the thermal heat seal type of bond of the present application, require a drying step and have other limitations.

Generally the thermoplastic elastomers are employed as the material for forming of various end products, 30 coatings, and the like. Such materials have the characteristic



of vulcanized rubber while permitting the rapid processing advantages of the general class of thermoplastics and have generally been employed in molding and similar forming of end products. Various thermal methods of bonding thermoplastic elements such as polyethylenes to each other employing an interposed bonding agent have been described in the prior art. Methods of bonding such plastic elements to each other employing an interposed bonding layer are disclosed, for example, in U.S. Patent 3,461,014 to James and 3,574,031 to Heller. The latter patent particularly discloses carrier elements incorporating suitable energy responsive particles which are dispersed throughout the carrier element. By subjecting the assembly to a suitable field the interfaces are converted to another state to form a firm thermal bond. The above and similar prior art has provided for joinder of various plastic members. Like elements of polycarbonates, polypropylene and the like have been bonded to each other where a low strength weld is acceptable by a direct thermal weld, but in many applications the melting of the material is not desirable. Also, as noted above, certain plastic materials such as polycarbonates, polypropylene and the like present particular bonding difficulties when employing an interposed bonding agent. Generally a bond of the elements to glass and the like has not been feasible.

#### Summary of the Present Invention

The present invention is directed to a unique bonding method employing a solid thermoplastic elastomer of a block structure in the form of a thin film as an interposed bonding element between non-elastomeric surfaces and effecting a fusion bond by heating of the element to a

fusion bonding temperature. Although, within the broadest aspect of this invention, any thermoplastic elastomer may be employed in bonding of appropriately related non-elastomeric surfaces, the inventors have found that the block-type elastomers provide unique fusion bonding, and particularly when selected from the group consisting of a copolyester block elastomer such as an elastomer derived from terephthalic acid, polytetramethylene ether glycol, and 1,4-butanediol; and a copolymer block elastomer such as an elastomer of rigid polystyrene end blocks with a polybutadiene, a polyisoprene, a ethylene-butylene or a ethylene-propylene-rubber-type center block; or a radial copolymer, such as an elastomer of polybutadiene center and rigid polystyrene end blocks. The copolyester elastomer provides a particularly satisfactory agent producing a bond which is vastly superior to the conventional pressure sensitive adhesive bonds, and to those obtained with other thermoplastic elastomers. Where bonding to certain material such as glass, the inventors have discovered that a primer such as phenoxy resin is advantageously applied to the glass to enhance adhesion of the copolyester elastomer element to the primer. This creates a firm bonding of polycarbonate or the like to glass. Desirable bonds can be obtained with elastomeric bonding agents by heating of the bonding elements to a state approaching a semi-liquid or molten without necessarily simultaneous melting of the elements to be bonded. For example, polypropylene and polycarbonate elements are firmly bonded to like and to different elements by employing a thin solid film of thermoplastic elastomer interposed between such elements to be bonded and heated to melt the elastomer and form a fusion bond. The procedure creates a bond which, with

an integral joining of the materials, is of a significantly superior strength.

The solid film may be provided with bond enhancement material such as the resin of one surface to be bonded, or the resin of the other surface, or both.

Although not essential, the thermoplastic elastomeric bonding film is preferably and uniquely heated to its melting temperature without simultaneously heating the elements completely to their melting temperature. The film is, in accordance with one unique feature of the preferred embodiment, heated by a field means which generates heat within the film and thus rapidly raises the film to the bonding temperature without causing any adverse effect on the elements. The previously identified Heller patent discloses a particularly satisfactory method of heating a film employing hysteresis losses in non-conductive particles within the carrier element. Other field phenomena may, of course, be employed. For example, dielectric heating may be employed if the thermoplastic elastomer has a sufficiently high dielectric loss characteristic or suitable high loss particles may be placed within the carrier film such as broadly referenced in U.S. Patent 3,574,031. Radiant energy may also be employed by introducing carbon black or the like into the thermoplastic elastomer carrier element.

In the more particular aspects of this invention, applicants have discovered that the elastomeric bonding agent produces highly reliable bonding of elements of non-elastomeric thermoplastic, such as polycarbonate, polypropylene and polyvinyl chloride to themselves and one another,

as well as the bonding of such elements to other dissimilar nonelastomeric thermoplastic elements and even nonplastic elements. Thus, polycarbonate elements and polyvinyl chloride elements can be joined to themselves with a high strength bond such as 125 pounds per inch width of 180° peel strength employing a thin bonding element of copolyester elastomer such as sold by DuPont under the trademark Hytrel #4055 and 4056. Such a bonding element is also highly satisfactory for bonding of polycarbonate elements to polyvinyl chloride and either of such elements to polyvinylidene chloride (PVDC).

The block copolymer elastomeric element sold by Shell Development Company under the trademark Kraton G provides a highly satisfactory agent for bonding of polypropylene to high density polyethylene using just a single layer of material. A bond strength on the order of 50 pounds per inch of width in 180° peel strength is readily obtained. Further, Kraton 3000 has been found to bond high impact polystyrene elements to each other with a lap joint strength on the order of 500 psi. A "Solprene" elastomer of Phillips Petroleum Company and which is a radial block copolymer of polybutadiene center blocks and polystyrene end blocks bonds ABS (acrylonitrile butadiene-styrene) elements to each other with a lap joint strength of 240 psi.

The precise mechanics involved are not readily apparent nor does the literature suggest any reason to believe the block elastomers are satisfactory as interposed fusion bonding elements for fusion bonding non-elastomeric elements. However, such an elastomeric bonding element does bond non-elastomeric elements which have not previously been satisfactorily joined by a fusion bond with any significant strength levels, such as produced by the present invention.

The block elastomeric materials would appear to have certain characteristics which are related to producing a high strength or superior bond. In particular, the block elastomeric resin has a high degree of chemical  
5 stability.

In preparing an elastomeric bonding element with the dispersed heat-generating particles, the resin is melted and the heat-generating particles introduced and the mixture is then finally hot-pressed to form a  
10 film or sheet. The hot material could, of course, be extruded or calendered to form the desired sheet. While hot, and partly as accentuated by the heat generating particles, oxidation of the resin normally is created. The inventors have noted that, in fact, the elastomeric  
15 resin does not significantly oxidize. Addition of a chemical oxidation retarder such as employed in Hytrel 4056 improves the bond characteristic and would appear to support the above analysis. This characteristic of the elastomers combined with the ability to use a fusion  
20 bonding temperature generally less than the customary fusion bonding temperature of the non-elastomeric element or elements, appears to be a significant factor in the optimum structure and methods of the invention, and, particularly, contributing to the unique and unexpected  
25 bond strengths obtained by the combination of the elastomeric bonding element and the non-elastomeric elements to be joined.

#### Brief Description of the Drawing

The drawing furnished herewith illustrates  
30 a preferred construction of the present invention in which the above advantages and features are clearly disclosed as



well as others which will be readily understood from the following description.

In the drawing:

Fig. 1 is a partial schematic view showing an initial step in the process of the present invention for obtaining thermal bonding of a pair of non-elastomeric thermoplastic elements employing an interposed elastomeric bonding element having heat-generating particles as heat sources;

Fig. 2 shows a subsequent step in the bonding process of Fig. 1;

Fig. 3 shows an induction heating unit suitable for the bonding process of the present invention;

Fig. 4 shows the finished bonded assembly;

Fig. 5 shows a test fixture for testing the peel strength of the bonds; and

Fig. 6 is an illustration of a prior art type bond.

#### Description of the Preferred Embodiment

Referring to Fig. 1, the process of the present invention is shown in bonding a first thermoplastic non-elastomeric layer or element 1 to a second thermoplastic non-elastomeric layer or element 2 by a thermal bond at overlapping joinder interface portions 3 and 4. A bonding element 5 of an elastomeric material is interposed between the elements 1 and 2 at the interface portions 3 and 4. Layers 1 and 2 may typically be formed of any one of various plastics including those which have not been successfully joined by thermal bonding or only with weak bonds, such as typical polycarbonates, polypropylene and high density polyethylene.

The term "elastomeric" element is employed herein to define that class of thermoplastic material possessing the properties of high resiliency or memory and containing copolymers and terpolymers.

5 In a particular unique teaching of this invention, the block-type elastomers are employed as a unique interposed bonding element for fusion bonding of non-elastomeric elements. Such materials have a rubber-like characteristic and have been found by the present inventors to produce highly effective fusion bonding of non-elastomeric thermoplastic elements. A discussion of elastomers as to structure, application and characteristic is set forth in the 1976-1977 edition of MODERN PLASTICS ENCYCLOPEDIA (Pages 103-108), as well as in the early 1975-1976 edition (Pages 94-96). As disclosed therein, these materials have been widely employed and are well-known in the art of molded products, conventional glue and/or adhesive sealants. Further, such materials generally are chemically stable and are not subject to significant oxidation when melted. Typical elastomers which have been employed in the present invention include a copolyester block elastomer derived from terephthalic acid, polytetramethylene ether glycol, and 1, 4-butanediol manufactured and sold by E. I. duPont de Nemours & Company, Inc. under the trademark Hytrel; a copolymer radial block elastomer of polystyrene and polybutadiene sold by Phillips Petroleum Company under the trademark Solprene Plastomers, a block copolymer of rigid polystyrene end blocks and center blocks of polybutadiene, polyisoprene, ethylene-butylene or ethylene-propylene sold by Shell Development Company under the trademark Kraton, and particularly the last two center-block types sold under the trademark Kraton G.

The elastomeric material selected for bonding element 5 is uniquely related to the material of elements 1 and 2 for optimum results, as set forth hereinafter in the discussion of the several elastomeric materials described in the latter article.

In the illustrated embodiment of Fig. 1, heat source particles 6 are incorporated in the bonding element 5 and are preferably particles which are responsive to a suitable high frequency magnetic energy field to form individual heat sources for rapidly heating of the surfaces to a bonding temperature. The particles may be incorporated into element 5 in any suitable manner such as by the selective insertion and mixing during extrusion of such an element, mixing and rolling or pressing a hot mix of the resin and particles, heating of the plastic element to soften the interface and pressing the particles into the plastic or the like.

The heat generating particles 6 are selected to form individual heat sources in the presence of suitable energy field. For example, different particles may be activated by suitable high frequency, alternating magnetic and electrical fields. The separate susceptor particles may, of course, be responsive to other fields such as a radiant field, including infrared radiation in which case the susceptor particles may comprise carbon black.

When a high frequency magnetic field is used as the energy source, the susceptor particles 6 preferably consist of fine particles of a ferromagnetic, nonconductive, metallic oxide selected from gamma  $\text{Fe}_2\text{O}_3$ ,  $\text{Fe}_3\text{O}_4$  and mixtures thereof which are responsive to the application of the high

frequency alternating magnetic field as more fully disclosed in the previously identified Heller Patent 3,574,031. Gamma  $\text{Fe}_2\text{O}_3$  has been found particularly suitable for use in the method of the present invention. The particles 6 may be incorporated in quantities of less than 2% to more than 50% by weight respective to the thermoplastic material, quantities of 10% to 30% by weight being typical. The unique ability of the aforesaid oxides resides in their ability to retain their heat generating characteristics even when reduced to submicron sizes. Particles sized as small as .01 microns may be used, although typically the particles may range up to 20 microns and in some cases may even be larger.

The use of the more minute particles facilitates incorporation into a thin bonding element with the advantages of the rapid susceptor heating of the bonding element to the melting temperature without simultaneously complete melting of the base plastic elements 1 and 2. The dispersion of the susceptor in the thermoplastic material as a result of the bonding does not appreciably alter the chemical or physical properties of the thermoplastic material.

Layers 1 and 2 with bonding element 5 interposed therebetween are located in direct abutment as shown in Fig. 2 and then exposed to the appropriate energy field. In the present embodiment, the particulate susceptor particles 6 in element 5 are activated by an alternating magnetic field which may be established by a coil 7, in accordance with known technology, such as diagrammatically shown in Fig. 3. The coil 7 is energized by the current of the high frequency alternating current power source 8.

High frequency power source 8 may typically operate in a frequency range of .4 to 5000 megahertz with a frequency range of 2 to 30 megahertz being typical for the conventional hairpin coil schematically shown in Fig. 3. A pair of opposed flat pieces of copper plates 9 and 10 are soldered or otherwise firmly affixed to the inner faces or side of the coil 7. The plates 9 and 10 in one unit were approximately one quarter (1/4) inch wide and several inches long. Force is applied across the tubing at the copper plates 9 and 10 in any suitable manner, as diagrammatically shown by the force arrows 11 and 12, to permit collapsing of the coil and plates 9 and 10 toward each other for applying pressure across elements located therebetween. By releasing of the clamping force 11 - 12, the assembled or stacked elements can be moved through the coil 7 to make successive seals or joiners.

The activated particulate susceptor particles 6 of element 5 increase in temperature and define dispersed heat sources along the bonding interface and rapidly raise the surface of only element 5 to the melting temperature with the elements 1 and 2 softened by conduction. Although a time on the order of a fraction of a second may be adequate with appropriate particle loading, power levels, and the like, longer heating times work equally well and may be achieved with less input power to coil 7.

As soon as the bonding element has reached the melting temperature, the application of the alternating magnetic field is preferably removed as by deenergizing high frequency power source 8. Thus, generally a good thermal bond to elements 1 and 2 requires that the element 5

is converted to a softened or viscous state. However, the element 5 must be retained between the surfaces or elements to form the bond.

In the procedure followed in each of the particular examples discussed herein, the bonding element 5 was formed by dispersing substantially 20% by weight of magnetic iron oxide ( $\text{Fe}_2\text{O}_3$ ) into the selected elastomeric resin and then hot pressing the particle-bearing resin to a thickness of substantially 8 to 10 mils. The substrate elements 1 and 2 were flat pieces of the identified plastic about 1 inch wide by 4 to 5 inches long. A 1 inch square bonding element 5 was located between the aligned ends of elements 1 and 2, as shown in Figs. 1 and 2, and the assembled elements were pinched within the coil plates 9 and 10. After heating to bond, the bonded assembly, as shown in Fig. 4, is removed and placed, as shown in Fig. 5, in a tensile machine 13 to determine the bond strength. In particular, the free ends 14 and 15 of elements 1 and 2 were bent open and placed in the jaws 16 of the tensile machine 13. Actuation thereof causes the jaws to spread and elements 1 and 2 to be pulled to separation, with the force required indicated by the tensile machine.

More particularly, non-elastomeric elements 1 and 2 formed of polycarbonate, polyvinyl chloride or PVDC, are bonded with a high strength joint by employing for element 5 a thermoplastic copolyester elastomer derived from terephthalic acid, polytetramethylene ether glycol and 1, 4-butanediol, such as made and sold by the E.I. duPont de Nemours & Company, Inc., Wilmington, Del. 19898, under the trademark Hytrel.

The copolyester elastomer is available in pellet and powder form and can be readily molded and formed. The material can be readily formed into a thin, solid bonding element 5.

In order to obtain optimum high strength joints when bonding polycarbonates, the copolyester elastomer element 5 was rapidly heated to melt and change the element to a highly viscous state.

- 5 Typical examples of bonding with a copolyester element, without detectable melting of the elements being bonded, are as follows:

Table I.- Peel Bond Results

	Elements 1 and 2, thickness	Bonding Agent Element 5	Heat Cycle Time	Peel Bond Strength, 1" wide
10	1/16" PC to PC	Hytrel 4055	1 sec	125 lbs
	1/8" PC to PC	Hytrel 4055	1 sec	162 lbs
	1/16" PC to 0.107" PVC	Hytrel 4055	1 sec	138 lbs
15	0.107" PVC to PVC	Hytrel 4055	1 sec	155 lbs

- The elements were clamped in place using air cylinders to apply pressure across the interface bonding portion and the R-F generator operated in the 2 - 7 MHz range. The generator was capable of providing current of several hundred amperes. The resulting bond strengths are unexpectedly high. For example, pressure-sensitive adhesive bonds in peel are generally on the order of 8 pounds per inch width while with the similar polyethylene layered bonding, such as suggested in U.S. Patent 3,574,031, 90 pounds is considered a high quality bond.

- Further, the direct bonding of polycarbonate materials has, heretofore, presented significant problems. Thus, conventional spin welding, ultrasonic welding and the like often creates embrittlement of the elements. When a

particulate heat source material is added to polycarbonate to form a bonding element, which is then directly thermally joined, as shown in Fig 3,

a stress can occur under test at the edge of the bond area, as at 17 of Fig. 6, resulting in failure. The failure occurs at the edge of the bond and has an appearance as if a cut had been made in the element. The bonding element does not appear in the area. Surprisingly, with the copolyester elastomer bonding element 5, such a failure has not appeared; even though the bonding temperature approaches the melting point of the polycarbonate.

Similar tests employing a thermoplastic rubber such as the TPR material of Uniroyal Inc., which is an olefin rather than a molecular block type elastomer was also used to bond 1/16" and 1/8" thick polypropylene to itself. A peel bond strength of 37 pounds resulted. This is a very low strength compared to those set forth in Table I. However, the polypropylene was readily and directly bonded whereas such material is otherwise, as with adhesives, generally bonded only with substantial difficulty. In this aspect, polypropylene has also been bonded to itself using a mixture of TPR elastomer and polypropylene. The results showed an improvement over the straight TPR elastomeric element 5 such as in peel strength.

The inventors have further discovered that polypropylene and high density polyethylene can be joined with a high strength fusion bond using a block copolymer elastomer in which rigid polystyrene end blocks are combined with ethylene-butylene, or ethylene-propylene-rubber-



type center blocks. Such material is available from Shell Development Company in solid form under the trademark Kraton G for processing into a bonding element 5.

5 Thus, a Kraton G resin was melted on a hot-roll mill and, while being milled, 20% by weight of susceptor particles  $\text{Fe}_2\text{O}_3$  were dispersed into the resin. The mixture was removed and hot-pressed into sheet form of 8 - 10 mils thickness. The Hytrel bonding elements used 10 in Table I were similarly formed. Various Kraton G grades were employed with Kraton G#2705 producing somewhat better bonds than #7827. Typical examples of bonding with Kraton G as bonding element 5 are as follows:

Table II. - Peel Bond Results

15	Elements 1 and 2, thickness	Bonding Agent Element 5	Heat Cycle Time	Peel Bond Strength, 1" wide
	1/16" PP to PP	Kraton G 2705	1 sec	43 lbs
	24-mil HDPE to HDPE	Kraton G 2705	1.5 sec	54 lbs
20	20-mil HDPE to HDPE	Kraton G 2705	1.5 sec	42 lbs
	20-mil HDPE to 1/16" PP	Kraton G 2705	1.5 sec	44 lbs*
	20-mil HDPE - HDPE	Kraton G 7827	2.0 sec	17 lbs

\* substrate broke at bond

25 A slightly better bond is again obtained with the dissimilar materials. However, this might be due to various practical reasons found in the normal functioning of the bonding and testing procedures and operations. The results in general are, however, highly significant 30 in view of the great difficulty which such non-elastomeric

thermoplastic materials have presented in past bonding practice. Although the bond strength is not as great as that found in heat sealing of more conventional thermoplastics such as polyethylene, a 50 pound bond is generally sufficient to prevent manual hand separation. Further, with the present invention employing the elastomer of a block-type structure, the bond can be repeated employing a conventional pressure bonding apparatus as heretofore discussed. An olefin elastomer TPR 1900 was also employed to bond two HDPE elements but only produced strength of 13 lbs. in peel.

In addition to the above embodiments, Kraton 3000 was employed to bond a pair of overlapping high impact polystyrene strips. The strips were approximately 1 inch wide by 1/16 inch thick. A one inch square, 0.008 inch Kraton 3000 bonding element loaded with 30% by weight of ferric iron oxide ( $\text{Fe}_2\text{O}_3$ ) was interposed between the overlapping ends of the strips and the assembly heated to the fusion temperature. The bond was tested by pulling in the plane of the strips and was found to have a lap strength of 500 psi. A Solprene elastomer bonding element was similarly applied to bond a pair of ABS strips and produced a lap strength of 240 psi.

Although described using a high frequency magnetic field, other heating means might be employed within the broadest aspect of this invention. Other particles might be employed which respond by induction, dielectrically or even radiation. Thus, metal conducting particles might be employed with induced eddy currents creating the heat within the bonding element.

Particles of polymeric type, useful as dielectric heating particles, would include the halogenated polymers such as the polymers and copolymers of vinyl chloride, vinyl fluoride, vinylidene chloride, and vinylidene fluoride and the polycarbonates, polyurethanes, polyacetals, and cellulose derivatives amongst others. The various elastomers such as Hytrel elastomer could also be employed as a bonding element without the necessity of added particles, by employing a suitable dielectric heater or microwave source of sufficiently high frequency, such as the order of 41 MHz. Further, Hytrel elastomers show a higher dielectric loss than, for example, polycarbonate and thus the necessary melting temperature could be generated in the Hytrel without melting the polycarbonate element to be bonded.

Radiant energy such as infrared energy may also be used in practicing the invention, with or without carbon black particles utilized as the susceptor particles to concentrate heat within the bonding element. An electric lamp and a reflector to focus the energy onto the element may supply the source of energy for heating the element which quickly melts. In radiant heating at least one of the elements 1 or 2 must necessarily be able to transmit a substantial portion of the infrared radiation in order for it to reach the element 5. In addition to energy sources such as infrared and lasers, it is to be understood that other forms of radiant energy such as X-ray, ion beams, electronic beams, ultrasonic beams, and nuclear radiation, amongst others, may be used for generating the heat in suitable susceptors selected as being responsive thereto.

A further significant bonding result has been obtained employing a primer between the elastomer element and a glass or the like. Thus, by applying of a phenoxy adhesive as a primer, the copolyester elastomer  
5 element bonds to glass. Thus by employing multilayers, vinyls, polycarbonates and the like can be firmly and directly bonded to glass.

Further, as the prior art has provided various similar material bonds, the elastomeric bonding  
10 element may, of course, include a minor amount of the non-elastomeric materials of the parent element being bonded. However, the elastomer remains the basic bonding element. For example, if a polyethylene and polypropylene are to be bonded, a 50-50 mixture of such materials in a  
15 bonding element does not produce a significant or satisfactory bond. Thus, the additive should constitute a minor part of the elastomeric bonding element.

Further, within the broadest features of this invention, the heat might be generated within the elements being  
20 joined and transmitted to the bonding element. The heat transferred would be sufficient to raise the bonding element to the fusion bonding temperature.

The present invention thus provides a unique method for bonding of plastic elements including such elements which  
25 have been previously bonded with difficulty.

THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. A thermal fusion bonding method comprising the steps of assembling thermoplastic non-elastomeric resinous component parts having a non-block-molecular-structure in stacked relationship to be joined over localized bonding interface surfaces with an interposed solid preformed thermoplastic and elastomeric resinous bonding element having a block-molecular-structure and located extending at least over the extent of the bonding interface, applying pressure over said surfaces to hold said element in firm contact with the interface surfaces, said bonding element having particulate material dispersed therein and generating induced heat in response to an energy magnetic field applied thereto, mounting said assembly in an air atmosphere at a temperature substantially below the softening temperature of the component parts and the bonding element, and during a period of applying said pressure applying said energy field to said bonding element to create heat within said particulate material and thereby said bonding element, and wherein said particulate material in said element serves as the only source of heat at the bonding interface surfaces of said component parts, applying said field for a time period on the order of up to 10 seconds and thereby raising the bonding element to its melting temperature and maintaining the component parts below their melting temperature and thermally bonding of the bonding element to the bonding interface surfaces of said component parts without significant physical change in the component parts, said heat in said element being insufficient to raise the temperature of said component parts substantially above the environmental temperature and thereby to preclude any significant change in said preformed

component parts while achieving a thermal bond strength between said component parts measuring in excess of 40 pounds per linear inch when tested in 180-degree peel configuration.

2. The method of claim 1 wherein said particulate material is electrically nonconductive and has a high magnetic coercivity.

3. The bonding method of claim 1 wherein said particulate material is a gamma ferric oxide ferromagnetic powder, and said magnetic field has a high magnetic field intensity at the bonding element and a frequency less than 10 MHz.

4. The method of claim 1 including selecting the energy activatable particulate material from the group consisting of  $\text{Fe}_2\text{O}_3$  and  $\text{Fe}_3\text{O}_4$ , and said radio frequency magnetic field has a frequency less than 10 MHz.

5. The fusion bonding method of claim 1 wherein at least one of the component parts is formed of polypropylene and the other part is selected from polypropylene and a high density polyethylene member, said solid elastomeric bonding element being block copolymer of rigid polystyrene end blocks and a saturated olefin rubber midblock of ethylene-butylene or ethylene-propylene.

6. The method of claim 5 wherein said heating step is created on the order of two seconds.

7. The fusion bonding method of claim 1 wherein at least one of said component parts is a polycarbonate and the other is selected from the group consisting of polycarbonate, polyvinyl chloride and polyvinylidene chloride

1125155

over an interface bonding portion, and said solid elastomeric bonding element is a block copolyester of terephthalic acid, polytetramethylene ether glycol, and 1,4-butanediol.

8. The method of claim 7 wherein said heating step is created on the order of two seconds.

